METEOROLOGY IN RUSSIA.

BY

Dr. A. WŒIKOF,

OF THE RUSSIAN IMPERIAL GEOGRAPHICAL SOCIETY.

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The first meteorological observations in Russia were made about the middle of the eighteenth century. The points of observation were few, scattered irregularly over the country, with very different methods and instruments. About the end of the last century attention was directed to that distant but highly interesting land, Siberia. The natural history of the country having been studied by Lepechin, Pallas, Gmelin, and others, the necessity of investigating its climate was also felt. Some efforts were made in this direction; thermometers were distributed, but the result was not encouraging, and we know next to nothing relative to these first Siberian observations. Even at the beginning of the nineteenth century the necessity of the study of meteorology was not generally recognized in Russia, and only as late as about 1820 were the number of points of observation increased. Between the years 1820 and 1835 meteorological observations were made in about thirty places, generally by private individuals, without any unity of plan, and often with imperfect instruments. Probably even many of the journals kept at that time were lost to science, for every observer worked by himself, and had generally no communication with each other and the leading savans of the time.

The great impulse given to the study of magnetism in 1828 had an influence on meteorology. In that year the "magnetische verein" was founded in Germany, and its president, Baron Humboldt, made great efforts to induce the Russian government to establish magnetical observations in its dominions. The Academy of Sciences warmly seconded this effort, and in consequence magnetical observatories were established at St. Petersburg, Kasan, Nicolajef, Sitka, and Pekin, and sometime afterward at Catherinenburg, (Ural,) Barnaul, (West Siberia,) and the mines of Nertschinsk, (East Siberia.)

In 1833 Kupfer presented a plan of reorganization of the magnetical observatories, so as to include meteorology. He was supported by the minister of finance and the chief of the engineers of mines, K. W. Tchefkine. This plan was approved by the Emperor Nicholas, and, like the system of magnetical observations, was placed under supervision of the department of mines, with its center at St. Petersburg. Magnetical and hourly observations were to be made at the following places: St. Petersburg, Barnaul, Catherinenburg, and Nertschinsk, and,

in addition, meteorological observations at Bogoslovlsk and Zlatouste, (Ural) and Lugan, (Southern Russia.) The observations were to be published at the expense of the department of mines: and Kupfer was appointed director of the system. All this was accomplished between 1835 and 1841. The observatories, however, of Nicolajef, Sitka, and Pekin were not under Kupfer's direction, nor was that of Tiflis, founded in 1844. A yearly publication, under the title of "Annuaire magnetique et meteorologique," was devoted to the meteorological observations of the stations of the department of mines, as also to those of Sitka, Pekin, and Tiflis.

In 1849 the Russian central physical observatory was founded. No change was made in the position of the principal points, but the observatory entered in communication with private observers, furnished them with good compared instruments, and published the daily means of their observations, as also those of the government stations, in a quarterly volume named "Correspondence meteorologique." The publication of the hourly observations of the principal stations continued under the title of "Annales de l'observatoire physique central." Thus for the first time a general system of meteorological observations was founded in Russia. New observers volunteered to assist in the work, and public institutions took part in this movement. The department of public lands furnished good instruments to its schools of agriculture, and some of their observations are very valuable. Mr. Wesselovsky stimulated their zeal and began at the same time to collect the meteorological journals of private observers, for a general work on the climate of Russia. Many journals were thus saved from oblivion, and the results of many private exertions were placed in the reach of the scientific world.

His "Climate of Russia" appeared in 1857, and, being still the most extensive and complete work on this subject, I may be allowed to give an account of its contents:

The author having the intention of publishing a strictly climatological work, with a view to apply his researches to statistics, and especially to the influence of climate on man, unfortunately excluded all that relates to the pressure of the air. Extensive tables are, however, given of the mean temperature for one hundred and forty-seven stations, in which number twenty-six are for Siberia and Russian America, with a clear exposition of the principal features of the distribution of the temperature, and an appendix on the heating power of the sun's rays and the temperature of the soil. A table is also given of the freezing and opening of one hundred and forty rivers and lakes. In this respect the compiler, Mr. Wesselovsky, was favored by the particular position of the rivers of Russia, and the attention always paid to this subject. Yet the collection of much of the datawas due to his strenuous exertions. We are presented with an unbroken record of the time of freezing and opening of the Neva, at St. Petersburg, reaching back to 1706, that is, for one hun dred and sixty-seven years, and records of from eighty to one hundred

years for about ten other places. The most important part of the work relates to the winds. Wesselovsky was the first to prove that in southern Russia the winds are easterly in autumn and winter, while in the center and northern part of the country they are from the southwest at this time of year, the same as in England and Germany. These relations of the wind to the seasons were exposed with the greatest clearness, and the new data since collected have only confirmed Wesselovsky's views; as I shall afterwards show, surprising as it may appear, the anemology of Russia and Siberia is even now misunderstood, especially by foreign meterologists. A chapter on vapor, clouds, rain, and hail follows. The observations were very few, while these phenomena, being local, can only be well studied when we have a great number of observations. The last chapter of the work is also of great importance; it treats of the changes of climate, and presents conclusive evidence that appreciable changes have not taken place in historical times. By consulting the classical authors, Wesselovsky shows that the general opinion that the climate of Southern Russia has become milder has no foundation. If Ovid, banished to the countries of the lower Danube, is astonished at the rigor of the climate, this is quite natural for a southerner. The Danube froze at that time as it freezes now, at least in its lower parts. The facts related by Herodotus relative to Scythia are still more important. At that time, as now, rains and thunder-storms were frequent in summer, and this was new to a Greek, accustomed as he was to a rainless summer in his own country, while the rains of winter were less abundant in Scythia than on the shores of the Mediterranean.

Herodotus also tells us that Southern Russia was a steppe, [1] at his time, as it is now, and probably has been during the whole of the present geological period.

The freezing and opening of rivers affords the author another proof that the climate has not changed in this respect since the beginning of the eighteenth century; at least that the time when the temperature is below the freezing-point is now the same as before. There is certainly a great variation in this respect in single years, and even in periods of from ten to twenty years. But nothing indicates a permanent change of climate. Cold years are followed by warm ones, and vice versa. If we take periods of thirty years at St. Petersburg, we have as follows:

Years.	Freezing.	Opening.	Days frozen.
	November.	*April.*	
1724–53	25.7	22.6	148.7
1754–1783	29.7	20.6	143.4
1784–1813	22.0	23.2	153.2
1814–1843	26.9	19.5	144.6

[1] Jreeles' region, prarie.

If we take periods of sixty years the difference is still less.

Years.	Freezing.	Days frozen.
	November.	
1724–1783	27.4	145.1
1794–1853	24.5	147-9

The Düna at Riga, where we have some observations made in the sixteenth century, gives a similar result. The average time of the opening of the river, in forty years of the sixteenth century, was April 9.6; in ninety-one years of the eighteenth century, it was April 7.2; in fifty-four years of the nineteenth century was 8.4. The Dwina at Archangel and the Dnepr at Kiev also show very slight differences between this century and the last.

The second part of Wesselovski's work contains extensive tables invaluable to the meteorologists. The mean temperature, the number of rainy days, and amount of fallen water, are given for every month of every year, so far as he could obtain the data. This collection of observations is extremely important for the study of the non-periodic variations of the meterological elements. The freezing and opening of rivers is given for every year separately, and it is much to be desired that such tables should be obtained for other countries. As yet they are very few in number, and no country of any considerable extent has tables of this kind comparable to those given by Wesselovsky.

About the year 1850 the geographical society of Russia began to collect information on the climate of the empire. No society or institution has the means of enlisting the co-operation of so many meterological observers as this society, it being widely known throughout the country, and having a great number of correspondents. It was thought necessary to collect topographical descriptions of different places, as a foundation of local climate, as well as observations of the periodical phenomena. In 1857 a meterological committee of the society recommended the establishment of a periodical devoted to the meteorology of Russia, as well as to allied branches of this science. The society adopted this recommendation, and the journal known as the "Repertorium für Meteorologie" was established under the directorship of Kämtz from 1859 to 1863. Three volumes appeared and were highly valued by men of science. The most important contribution was by Kämtz, "Klima der südrussischen Steppen." About this time, especially since 1860, a general belief was entertained that the system of meteorological observations established in Russia had proved a failure, the money given by the government had been expended to little purpose, that the whole system required reorganization. As is generally found in such cases, there was considerable truth, and also a great deal

of exaggeration in this opinion. The enormous extent of country over which the meteorological stations were scattered prevented their frequent revision, a condition necessary to the successful working of a meteorological system. The instruments of the stations were not frequently enough compared with the standards. All this certainly rendered the observations less valuable than they would otherwise have been, yet the location of the observatories, especially those of Barnaul and of Nertschinsk, in a country the study of which is especially important to meteorology, rendered even second-rate observations valuable. On the other hand, the liberality of the Russian government in publishing the observations in full was of great use to science. It is only within the last ten or fifteen years that we have learned the great value of actual observations, while in former times monthly means were thought quite sufficient. The Russian publications were not valued as highly as they merited, because they were in advance of their time, and we are now able to say that the system of observations and publications established by the Russian government was not a failure, but rendered good service to science.

About the year 1865 efforts were made to extend the meteorological observations and establish a system of telegraphic bulletins. The ministers of the navy and public instruction took an interest in the enterprise, but the practical result was next to nothing.

After the death of Kupfer, Kämtz was nominated director of the physical observatory. Extensive reforms in the organization of the meteorological system began at this time, and were continued by his successor, Dr. H. Wild. The physical observatory is now placed under the authority of the academy of sciences, and that body has the choice of its director. A new set of instruments was ordered to be made, compared at the observatory, and sent to the different stations. The centigrade scale for the thermometer, and metrical divisions for the barometer, and rain-gauge have been in use since 1870, so that nearly the whole continent of Europe have the same measures for the meteorological instruments. The German meteorological system, directed by Dové, alone forms an exception, having the Reaumur scale for the thermometer and the old French measures for barometer and rain-gauge. The form of publication was also changed; hourly observations had ceased since 1868 except at Tiflis, and it was decided to publish the observations made thrice a day, without any difference between stations maintained by the government and those of private observers. The first Annales published in this way were those of 1865; those of 1866, 1867, and 1868 were in the same form, while the observations of 1870 and 1871, made after the new system, are already published, and those of 1872 in active preparation. No meteorological system in Europe has a publication of the same importance, for it must be repeated that original data are especially necessary in the present condition of science. These data must be printed to render

them most useful, and also to place them within reach of every student of meteorology. This is generally recognized by all men of science in Europe, and they would establish a similar system of publications if only the money could be procured to defray the expense. In the present position of central and western Europe this is very difficult, as the expenditure for military operations has increased to the utmost, and the governments are very economical in their appropriations for scientific purposes. Happily Russia is now in a better condition, and can afford to devote more means to the cultivation of science and other truly useful purposes.

We have seen that the system of publication adapted in Russia is commendable. The other points of the system are far from being as good. (1.) There are too few stations in many parts of the country, especially in the North and in Siberia. (2.) The stations are too seldom visited, and their instruments compared with standards. (3.) The practical applications of meteorology are lost sight of by the physical observatory. The inconvenience arising from the too great distance of the stations from the central observatory has already been recognized. Wild proposed to have branch central observatories in the university towns, and some other principal cities of the empire, the director of which would each have the supervision of a part of the country. The directors of these observatories would inspect the stations as often as possible, and compare their instrument with standards. The central physical observatory at St. Petersburg would have to determine as to the system of observation and registration to be adopted, and to reduce, discuss, and publish the observations from all parts of Russia. It was proposed to have such branch observatories in Moscow, Kasan, Charkof, Kiev, Odessa, Dorpat, Warsaw, and Helsingfors, Wilna, Tiflis, Irkutsk, Taschkend, and Pekin which would complete the system. At Tiflis the system is in operation, as the director of the observatory at this place has the control of the observations made in the Caucasian provinces, inspects their instruments, &c., and sends their observations, after discussion, to Petersburg to be published. Unfortunately this system of centres could not be fully realized for want of means. The principal reason why the meteorological system of Russia, so excellent in many respects, cannot be completed as was intended, is that meteorology has not been practically applied in Russia, and the observatory has not interested the people at large in its principles and importance. This is true to such an extent that very few, even in St. Petersburg, have an idea of the existence of a central physical observatory. Indeed the notion is prevalent that meteorology is a part of the operations of the astronomical observatory of Pulkowa; this being the case, a much less number of observers are willing to do the work imposed by the regulations of the government, and for which they are not paid, because they do not have a definite notion of what becomes of their work when it is sent to St. Petersburg. Some of the former observers have refused to undertake the greater

amount of labor necessary in carrying out the new system, and certainly there are many of these who are quite unknown to men of science, whose laborious efforts have in a great measure been lost for want of proper instructions of what and how to observe. A second drawback experienced in carrying on this system is the difficulty, to which we have before alluded, of getting the additional grant of public money so necessary to the further progress of meteorology as well as to its practical application. So far from interfering with the progress of pure science, the practical applications, in extending the number of observations and increasing the number of men interested in science, can only conduct to new discoveries.

In speaking of practical appliances I, of course, refer to the system of weather telegrams and predictions so extensively used at present in the United States.

As some of the general movements of the atmosphere have been determined, and it is known that in Russia the storms move from west to east, as they generally do in the middle latitudes of the globe, we are in a very favorable position for the prediction of the weather, much more so than those in Western Europe, and scarcely less than in the United States. As a great many meteorological stations exist in the west of Europe, it is easy to obtain telegraphic communications relative to the weather from them for the mere expense of the telegrams. The Norwegian meteorological institute has already established forewarnings of storms, and it would be only necessary to establish telegraphic lines to the shores of the Arctic and White Seas, for the benefit of the shipping and fisheries of these regions. The western part of Russia, with the Arctic, White, Baltic, and Black Seas, would thus mainly depend on intelligence received from abroad, while the railroad officials and travelers inland could be warned of the approach of storms of snow and rain by the intelligence received from Western Russia. The delays on the railroads and the great loss of life which frequently occur on ordinary roads could thus to a great extent be prevented. After the climatical features of Russia have been sufficiently studied, agriculture itself would profit by the warnings of heavy rains and thunder-storms predicted in advance; they would be prepared for and lose a part of their baleful influence. Within the three last years the geographical society has again busily occupied itself in promoting the study of meteorology in Russia, and the success of the first two years of this work is very encouraging. The geographical society did not, however, wish to interfere with the business of the physical observatory, yet the inability of this institution to perform all the labor was too clear to be ignored. It was proposed to elect a meteorological commission from among the members of the society. This commission was elected in the beginning of the year 1870, and discharges the duties of meteorological societies in other countries; that is, it furnishes the theoretical and practical propositions of the science.

A general system of rains and thunder-storm observations was commenced, in the prosecution of which the society was much favored by its extensive correspondence throughout the country. Circulars explaining the necessity and mode of observations were sent to the corresponding members, to various schools, to the presidents of the district assemblies, &c. A cheap rain-gauge was also adopted, of which the principle is simple and its use easy to understand. Of these there were about sixty new observers in the spring of 1871, while all the necessary preparations were not completed until the autumn of 1870. A year later the number of observers had increased to about two hundred, and this state of things continued to be very promising up to the time when I left St. Petersburg, in December, 1872. The success of this effort proves that it is not difficult to find many persons willing to work for science, even if an immediate practical result is not expected, provided only that the final utility of the results is properly explained.

To obtain this very desirable result it was necessary to publish and send to the observers papers on meteorological subjects, which would tend to awaken and sustain their interest in the subject. This was done by the geographical society in Nos. 1 and 5 of its "iswastia" which contained papers of this kind, copies of which were sent to all observers, and generally distributed. Being secretary of the meteorological commission, I was charged with the duty of drawing up the result of the first year of observation, from December, 1870, to November, 1871. The results obtained were better than could have been expected from the variable nature of aqueous precipitation. It was even possible from the data to draw isohyetal lines, the first ever attempted in Russia, for the months of May, July, August, and September, 1871. It was found easier to draw isohyetal lines for one single month than for means of different years in different places. As to the thunder-storms, it was less easy to obtain general results from the few observations made in 1871; maps could not be drawn from them. On the other hand, the results for the direction of thunder-storms and the hours at which they occurred were satisfactory. The most prevailing direction was from southwest, next from south,southeast, west and northwest, while from the other directions their appearance was very seldom indeed. The hour of the most frequent occurrence of thunder-storms was about 3 p. m. At some stations situated from one hundred to two hundred and fifty miles east of the Ural mountains a second hour of maximum occurrence existed late in the evening. As the storms move from W. to E. these latter ones evidently originated in the Ural mountains, where it is known that frequent and very violent thunder-storms occur in summer, and moving eastward arrived later in the day. A similar feature could be noticed in the southwestern group, Kiev, Podolia, and Volhynia. They are to the east of the Karpathians, and the thunder-storms from that quarter reach them in the night.

The geographical society further decided to devote a volume of its

("Sapiski") memoirs entirely to meteorology, especially to investigations relative to the climate of Russia. The reason of this decision was the desire that was felt to have this subject thoroughly investigated, so as to produce a work on the level of the science of our time, as Wesselovski was of that of sixteen years before. It was hoped that the members of the meteorological commission would contribute to the desired result, which could only be attained by the united efforts of many laborers. The plan of periodical publication of the society "Isvastia" was not well adapted to meteorological works of great extent, being principally devoted to the progress of geography. The Siberian section of the geographical society at Irkutsk has also established a meteorological commission, with the same powers as that of St. Petersburg. Many observations made in Eastern Siberia are reduced and discussed there, and much progress in the science may be expected from that quarter. There are few countries so interesting to meteorology and yet so little known as Eastern Siberia. It includes the meteorological pole of winter—that is the coldest region in this season—and besides embraces an enormous extent of country, with every variety of local climates.

A secondary meteorological center at Irkutsk is also very important for the supervision of stations and comparison of instruments. It is next to impossible to effect these objects from St. Petersburg.

It would be going too far to mention the efforts of the various government boards and societies to establish systems of meteorological observations in different parts of Russia, the more so as a unity of directions is now shown to be necessary to the progress of this science. Most of these systems are now united with that of the physical observatory, having adopted the same measures and methods. This is the case with the navy, which has meteorological stations on the White, Baltic, Black, and Caspian Seas, and also on the Pacific coast.

We shall now give a brief exposition of what is known of the climate of Russia, what are the advances made in latter years, and what remains to be done in this respect.

Our knowledge of the temperature of Russia is far more complete than that of the other meteorological elements. A striking fact has been brought to our knowledge in the last ten or fifteen years, that the mean temperature of winter is higher on the shores of the Arctic Ocean than to the south of it on the same meridian. Near the North Cape it is higher, even if we advance from southwest to northeast, while in the rest of Europe the northeast is the coldest quarter. This is due to the warm waters of the Gulf Stream, which flows along the north coast of Norway, and farther along the Russian Murman coast as far as the Svjatoi Noss, (Holy Cape.) The waters in this region never freeze, even masses of floating ice are never seen in them, and they communicate their temperature to the surrounding air. The places in the interior of the continent, far from the warming influences of the Gulf stream, will natur-

ally have a lower winter temperature. No long meteorological observations have been made on the Murman coast, but the cities of Northern Norway situated on the same ocean, and subjected also to the influence of the Gulf stream, have a very similar climate. For the consideration of the winter and summer temperature of the same meridian from north to south we will refer to the following table:

Meridian about 22°.

	Winter.	Summer.	Diff.
Hammerfest, 71° N	23.9	49.0	25.9
Torneo, 66° N	6.4	57.9	51.5
Helsingfors, 60° N	20.7	59.0	38.3
Mitaw, 57° N	24.8	62.1	37.3
Warsaw, 52° N	27.0	63.5	36.5

Meridian about 29° E. from Greenwich.

	Winter.	Summer.	Diff.
Wardoe, 70° N	21.9	45.9	24.0
Petersburg, 60° N	17.4	60.8	43.4
Gorki, 54° N	18.1	61.5	43.4
Kiev, 50° N	22.6	65.3	42.7
Odessa, 47° N	27.9	70.3	42.4
Sevastopol, 45° N	36.9	72.7	35.8

We see that Wardoe has nearly the same temperature in winter as that of Kiev, situated 20° to the south on the same meridian. Even far from the shores of the Arctic Ocean the increase of temperature from north to south is very slow. It is accelerated only when we approach the shores of the Black Sea. Here again the warming influence of the salt-water basins is felt, while the temperature of summer also increases rapidly, and this for the reason that South Russia is principally a steppe, (prairie,) and such treeless regions are more heated by the sun than those covered with woods.

In the case of increase of temperature from north to south, Northern and Central Russia are very different from the United States, the former having the least and the latter the largest increase of temperature from north to south known in any extensive region. This increase is as follows in Russia, for 1 degree of latitude in degrees of Fahr.:

	Year.	Winter.	Summer.
From 64½° N. to 50° N	0.70	0.58	0.76
From 50° N. to 42° N	1.78	2.79	0.81
Difference	1.08	2.21	0.05

The temperature of the winter is also higher on the western coast of Nova Zembla than in the northeast of European Russia and Western Siberia. It has been found to be 5.7 on the 74° north in Nova Zembla, while it is — 6.5 at Berezov, (64° N.,) 1.6 at Ischim (56° N.,) and 10.2 at Kasalinsk, on the lower Syr-Daria, (46° N.,) so that it is only 4½°. higher, for a difference of 28° of latitude. The mildness of winter temperature on the Arctic Ocean is also illustrated by the fact that, while this ocean does not freeze so far as the Swjotoi Noss, the Caspian and Azov Seas, in a latitude of about 46°, freeze to a great extent.

The observations made in Russia furnish us with the means of tracing the changes of temperature from east to west, from the Atlantic to the Pacific Ocean. Generally the winter temperature decreases as we advance into the interior of the continent from west to east, and increases a little on the eastern shores of Asia. Yet, being much lower there than in Western Europe, the temperature in the interior is a little higher in summer than near the Atlantic, and decreases very rapidly near the Pacific, being much colder there than anywhere else on the same parallel in Europe or Asia.

Parallel of 70° N.

	Winter.	Summer.	Diff.
Wardoe, (Norway,) 29° E	21.9	45.9	24.0
S. E. coast of Nova Zemla, 57° E	3.2	35.6	32.4
Ustjavsk, 138° E	— 35.9	46.8	72.7

Parallel of 62° to 64° N.

	Winter.	Summer.	Diff.
Thorshavn, Feröe Island 7° W	39.2	54.7	15.5
Soudmor, Norway, 6° E	27.1	55.8	28.7
Woro, (Finland,) 22° E	17.4	59.4	42.0
Ustsisolsk, 51° E	7.5	59.4	51.9
Berezov, 65° E	— 6.5	58.1	64.6
Jakutsk, 130° E	— 37.3	58.6	95.9

The difference between the limited climate of the shores of the Atlantic and the excessive climate of the interior of Eastern Siberia is strikingly illustrated by this example. The difference of the mean temperature of January and July in the last place is more than 100°, (January, — 41.4; July, 63.3.) Unfortunately we have no observations on the shores of the Pacific north of the 59th degree. The winter temperature would certainly be much higher there than at Jakutsk.

Parallel of 59° N.

	Winter.	Summer.	Diff.
Sandwick Orkney, 3° W	39.7	53.5	13.8
Reval, 25° E	22.3	59.0	36.7
Wologda, 40° E	12.9	60.8	47.9
Bogoslowsk, (1) 60° E	— 0.2	58.9	59.1
Ochotzt, (Pacific,) 143° E	— 8.1	52.1	60.2

Parallel of 56° N.

	Winter.	Summer.	Diff.
Glasgow, 4° W	38.8	57.2	18.4
Copenhagen, 13° E	31.3	62.1	30.8
Moscow, 37° E	14.7	64.3	49.6
Kasan, 49° E	11.0	64.8	53.8
Ischim, 69° E	1.5	63.6	61.1
Ajan, (Pacific,) 138° E	— 1.1	51.4	52.5

Parallel of 53° N.

	Winter.	Summer.	Diff.
Dublin, 6° W	41.6	58.6	17.0
Groningen, 7° E	35.1	63.5	28.4
Orel, 36° E	17.1	65.1	48.0
Pensa, 45° E	8.1	65.3	57.2
Barkaul, 34° E	1.0	64.9	63.9
Nicolajevsk, (Amoor,) 140° E	— 6.3	58.9	65.2
Petropavlovsk, Kamtchatka	20.3	55.5	35.2

Parallel of 46° N.

	Winter.	Summer.	Diff.
La Rochelle, 1° W	39.7	67.6	27.9
Venice, 12° E	38.8	72.5	33.7
Odessa, 30° E	27.9	70.3	42.4
Astrachan, 48° E	22.4	74.9	52.5
Kasalinsk, 64° E	10.2	73.6	63.4

(1) Above 700 feet eastern slope of the Ural.

Parallel of 39° to 40° N.

	Winter.	Summer.	Diff.
Lisbon, 9° W.	50.0	70.0	20.0
Naples, 15° E.	47.8	72.9	25.1
Lenkoran, (Caucasus,) 48° E.	39.9	75.6	35.7
Pekin, (China)	28.8	77.9	49.1

The difference between the east and west is less sensible in the lower latitudes than north of the 50th degree. Scarcely will the winter be found colder anywhere on the 40th degree than in Pekin, and yet the difference between this place and Lisbon, on the Atlantic, is only 26°, while the winter climates of Dublin and Nicolajevsk differ by 47.9, and yet in the last place the temperature is already milder, because of the proximity of the Pacific. Blagovestschensk, on the upper Amoor, latitude 50°, has a winter temperature of —8.5, while in Helston, in Southwestern England, it is 46.0; difference, 54.5.

The summer temperatures are much more equable, being lowest on the Pacific shore, (Ochotsk, Ajan, Petropavlovsk.)

The ratio of the change of temperature in European Russia from west to east may be adopted as follows, in degrees F. for 1° of longitude: For the year: —0.25; winter, —0.56; summer, 0.13, [1] that is, it increases very little in summer and decreases very rapidly in winter. In this last season the decrease from west to east and from south to north is the same.

The extensive plains of Russia and Western Siberia are very favorably situated for this kind of study, since the local peculiarities do not interfere with the result as much as in other countries. In Eastern Siberia the conditions are different; the country is intersected by many mountain chains; the vicinity of the Pacific modifies the climate to a great extent. On the other hand, as the points of observation are very widely scattered, it is not to be wondered that we know very little as yet of the climate of this interesting country. The pole of winter cold is situated, we know, at or near Jakutsk, on the Lena. As I have said before, the general system of meteorological observations did not extend so far northward, and it was a private individual, Mr. Neverof, to whom we are indebted for the twenty-five years' observations at Jakutsk. In Eastern Siberia, as in Western, the cold of winter is more intense in the interior of the continent than on the shores of the Arctic; the coldest known winter being at Jakutsk, latitude 62° N. In this respect Asia seems to differ very much from America, as here the coldest peninsulas and islands of the Arctic Ocean are far beyond 70° N.

The cause of this difference is probably that the Arctic north of the Asiatic continent is not entirely frozen, even in winter, while the nu-

[1] Hann, l. c., p. 394.

merous bays and sounds north of America are covered with an unbroken sheet of ice and snow. These bodies being very bad conductors of heat, their surface, and the air immediately overlying them, can cool to a great extent, as would a continent. These facts should be borne in mind when speaking of the climate of Eastern Asia and America, explaining the differences found, contrary to the general opinion of the similarity of the eastern shores of both great continents. The changes of temperature with elevation are also very much modified by the general features of Eastern Siberia, geographically and climatically. We know two high points of this country which have a higher mean winter temperature than the surrounding lowlands. These points are Mount Alibert 52° 30′ N. latitude, and 100° 41′ longitude E. of Greenwich, 7,300 feet high, and the mines of Wosnesensk, 58° 46′ latitude N., 115° 16′ E., 2,817 feet high.(1) I give here the temperatures of January as they were observed, and the supposed temperatures of the same points at sea-level, according to Dove's isothermal map.

Temperature, of January.

	Observed.	Supposed.	Difference.
Mines of Wosnesensk..	+13.0	—26.5	13.5
Mount Alibert.....	2.1	— 6.0	8.1

We see that these high points have a much warmer winter temperature than was supposed. Wosnesensk is not very far from Jakutsk, where the temperature of January is —41°4′, that is, more than 27° lower. Irkutsk is not far from Mount Alibert, and has a much lower winter temperature.

The increase with the height in winter in these two cases being shown, the question follows as to the cause. In clear, cold spring nights vegetables are often known to suffer from frost in low situations, while those on hills escape injury. This has long been explained by the action of radiation and gravity, when the air is calm. The colder and denser portions have a natural tendency to flow downward, and this tendency in a clear, calm night is not counteracted by the sun and winds, as it is generally during the day. Now a condition, analogous to that of spring, does prevail very generally in Eastern Siberia, especially in winter. The air is calm, the sky clear, the sun appears only for a short time, and the superposition of strata of air which would be caused by radiation and gravity is very little impeded. It is not to be wondered at, then, that a condition which is rare in Europe and the United States should be so common in Siberia, so as to raise even the mean temperature of high stations above that of low ones. A very general and strong

(1) For further particulars see "Zeitschrift der Österreichischen Gesellschaft für Meteorologie," year 1871, p. 52.

west wind was also noticed in winter at Mount Alibert, and described as a warm wind, while, as we have said before, calms with intense radiation prevailed in the lowlands.

These facts, as also much of what we begin to know about the plateaus of North America, show that the so-called laws of decrease of temperature with elevation are not generally applicable. The older notions on this point are taken from the observations in tropical South America and the mountain regions of Western Europe; that is, from maritime climates and mountain-chains. In regard to plateaus, these laws, we are sure, must be very different, but we are not able at present to state what they really are. In the present state of our knowledge we can only say that the decrease of temperature will be greater, first, in mountain-chains than on plateaus; secondly, in summer than in winter, or generally in warm temperatures than in cold; thirdly, in dry than in moist air.

The parts of Asia belonging to Russia present the most interesting problems relative to the influence of position on the distribution of temperature which can be found. Unfortunately these countries are scarcely emerged from darkness.

The range of temperature is an important element, which ought to be more studied than it is at present. I will refer only to an opinion very widely entertained in Russia, that the Siberian climate is very constant in comparison with that of Europe. This is erroneous, at least so far as Western Siberia is concerned, which has a very variable temperature especially in winter, scarcely less than that of the Mississippi Valley, so conspicuous in this respect.

The following table shows the mean highest and lowest temperatures of each month, observed with maximum and minimum thermometers, for twelve years, from 1851 to 1862.

Month.	St. Petersburg.			Lugan, (South-east Russia.)			Barnaul, (West Siberia.)			Nertschinsk, (2,000 feet,) (East Siberia.)		
	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.
January	35.4	−11.2	46.4	39.7	−15.7	55.4	28.2	−43.1	71.3	2.1	−42.9	45.0
February	34.0	− 8.5	42.5	40.5	−13.4	53.9	37.1	−36.4	68.6	17.4	−35.1	52.5
March	39.7	− 2.6	42.3	56.3	− 2.4	58.7	41.2	−27.4	68.6	40.6	−22.2	62.8
April	55.2	15.6	39.6	77.0	21.0	56.0	63.7	1.4	62.3	60.8	2.1	58.7
May	74.3	29.1	45.2	86.9	34.5	52.4	82.0	23.0	59.0	79.2	21.4	57.8
June	79.2	39.2	40.0	92.7	42.6	50.1	87.1	36.7	50.4	87.6	34.7	52.9
July	83.3	48.9	34.4	95.0	50.0	45.0	89.4	46.3	43.1	86.5	45.1	41.4
August	77.4	45.3	32.1	93.9	44.4	49.5	85.5	39.6	45.9	84.4	35.1	49.3
September	68.7	34.9	33.8	85.3	34.7	50.6	75.6	25.9	49.7	72.3	22.8	49.5
October	57.4	23.0	34.4	74.8	19.2	55.6	62.6	4.8	57.8	57.0	− 1.1	58.1
November	43.5	4.1	39.4	56.1	5.7	50.4	41.9	−22.7	64.6	33.8	−25.1	58.9
December	37.0	− 4.7	41.7	43.0	− 2.2	45.2	33.1	−34.6	67.7	11.1	−38 6	49.7

Barnaul, in West Siberia, has the greatest range of temperature, at least from November to May. In the winter Nertschinsk has a relatively small range; it is the constant winter of Eastern Siberia; in January the range is even smaller than at St. Petersburg. The maxima are clearly seen in Nertschinsk in March and November, while January and July have the least range. The temperature sometimes may fall as low in Western Siberia as in the eastern part of that country, only in the latter the cold is constant, and the thermometer never rises above the freezing-point from the first days of November to the middle of March. The following table gives the absolute maxima and minima of the winter months in the same period; to which I have added those of Jakutsk for ten years, 1845–1854, from observations taken thrice a day

Month.	St. Petersburg, absolute.			Lugan, absolute.			Barnaul, absolute.			Nertschinsk, absolute.			Jakutsk, absolute.		
	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.
Dec ..	41. 0	−17. 5	58. 5	52. 7	−33. 2	85. 9	40. 5	−67. 0	107. 5	27. 0	−44. 3	71. 8	0. 5	−64. 0	64. 5
Jan ..	38. 3	−31. 0	69. 3	45. 3	−31. 0	76. 3	36. 5	−64. 7	101. 2	14. 0	−49. 7	63. 7	0.	−63. 6	63. 6
Feb ..	37. 2	−23. 1	60. 3	56. 3	−25. 1	81. 4	42. 1	−58. 7	100. 8	28. 6	−45. 6	74. 2	11. 7	−60. 1	71. 8

The absolute range is less in January in Eastern Siberia than in any other of the given points, while it surpasses 100° at Barnaul. At this last point 36°.5 were observed on the 4th of December, 1860, and —67.0 on the 16th of the same month, being a difference of 103.5° in twelve days. These enormous variations of temperature have also been observed in the valley of the Jenissei—for example at Krasnojarsk, 33.1 on 28th of November, 1840, and —51.2 on the 30th, being 84.3 difference in 46 hours. In Eastern Siberia these enormous changes are unknown in mid-winter.

The pressure of the air has received much less attention in Russia than the temperature, and this can be said of the observations, as well as of their calculation and tabulation. We do not possess as yet good barometrical tables, although we may hope to have them, as *Lieutenant Rikatschef and Baron Maydell*, both of the physical observatory, are occupied with the reduction and discussion of all the barometrical observations which they could obtain in Russia. The largest collection of barometrical means for Russia is that in Buchan's work on "Mean pressure and winds."

The great summer depression of the barometer is strongly marked in Southern and Central Russia, and is perceptible even farther to the west. It probably attains its greatest amount on the plateau of Central Asia, from Eastern Turkestan to the Gobi, but we have not a single year of continued barometrical observation in this widely-extended country. The greatest amount of the summer depression known to us

was observed west of the plateaus, on the upper Irtysch and east of them at Pekin. The following table shows the distribution of pressure in different months:

	January.	July.	Difference.		January.	July.	Difference.
Western Europe.				*South and East Russia.*			
Reikiavig, (Iceland)	29.47	29.69	.22	Odessa	29.88	29.67	−.21
Greenwich	.76	.81	.05	Lugan	.83	.48	−.35
Hammerpest, Norway	.51	.73	.22	Samara	.80	.43	−.37
Udine, North Italy	.63	.58	−.05	Orenburg	.87	.44	−.43
Vienna	.38	.30	−.08	Astracan	30.22	29.88	−.34
North and West Russia.				*Caucasus.*			
Archangel	.74	.70	−.04	Redut Kale	.09	.84	−.25
St. Petersburg	.85	.78	−.07	Tiflis	28.55	28.29	−.26
Kostroma	.34	.15	−.19	Baku	30.21	29.81	−.40
Warsaw	.59	.44	−.15	*West Siberia and Central Asia.*			
Kiev	.88	.67	−.21				
Eastern Asia.				Bogoslovsk	29.28	29.05	−.23
Irkutsk	28.78	28.19	−.59	Catherinburg	29.13	28.78	−.35
Nertichinsk	27.96	27.56	−.40	Barnaul	.81	29.10	−.71
Pekin	30.24	29.67	−.77	Novo Petrovsk	30.08	.72	−.36

The monthly differences of pressure have only lately attracted general attention. The cause of this is that in Western Europe, Eastern North America, and the tropics, these differences are very small. It was only after the observations in Siberia, China, and India were known, that the barometrical depression of the summer was noticed, and the summer monsoon of India and China was explained by the rarefaction of the air in the middle of the continent, and the consequent drawing in of the air of the surrounding seas.

Now that the relations of the pressure to the winds are better known, much more attention is given to barometrical observations, and especially those of the Asiatic continent attract the attention of all meteorologists. There are two problems which remain to be solved here in regard to this matter: (1) Barometrical observations in the interior of Asia, to ascertain the true amount of summer depression at a distance from the influence of the ocean, and (2) a line of levels from the Baltic to the Pacific Ocean. So long as the true height of Siberian points of observation is not known, and the adopted heights may be wrong from 300 to 500 feet, we can know very little of the pressure of the air in this region. It is a *circulus vitiosus*, as the heights are measured by the barometer, and afterwards the observed barometrical readings are reduced to sea-level, on the supposition that the obtained height is true. The isobars drawn in Buchan's excellent work on the mean pressure are not free from this reproach, as any isobars must be so long as the actual height is not accurately known. The plan of a line of levels from the

Ural Mountains to Lake Baikal was discussed last year by a special commission of the Russian geographical society, and the importance of this work clearly pointed out. The council of the society, however, declined to undertake the work immediately for want of adequate means, yet it was hoped that private individuals would help the society in this important enterprise, the more so as it has a practical bearing. A line of railroad from Nijny-Novgorod over the Ural to Irkutsk, and from thence to the Amoor River, or directly to China, is in serious contemplation. Its feasibility is beyond doubt, as the difficulties are far from being so great as those of the American Pacific Railroads.

The barometrical minima have an important bearing on the production of storms, as it is now well ascertained that these violent commotions of the atmosphere are caused by a great barometrical difference between places near each other. Generally the barometer is very low in the center of a storm, this center drawing in from every direction the surrounding air. On the other hand, a great barometrical depression can only be sustained by the condensation of vapor; cold and dry continental areas will then arrest the progress of storms moving towards them. The coldest region of Siberia can have no storms in winter, if the foregoing views are correct. This is also the case; for example, at Nertschinsk, we find scarcely a moderate wind in the three winter months, calm or very light northwest winds being the rule. In Western Siberia calms prevail in very cold winter months, while the winds are stronger in warm winters. In considering European winter storms, *Mohn arrives at the following conclusions:

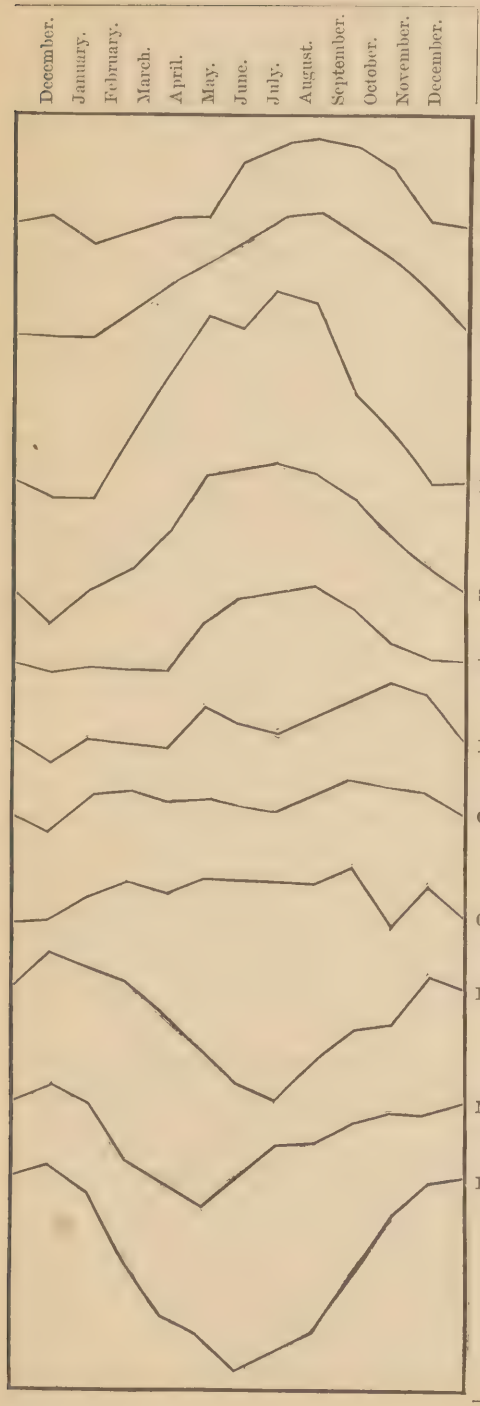
Storm-centers move from S. 71° W. in the Arctic and Atlantic Oceans, from N. 7° W. in Scandinavia and Germany, and from N. 27° W. in Russia. He says that the air is too cold and dry in Northern and Eastern Russia to sustain the barometrical depression; the condensation on the southern side is much greater, and so the storm moves southward, while the barometer rises in its center. The mean pressure in the center of storms is 28.68 inches over Scandinavia and Germany, and 29.13 over Russia.

Mohn has not attempted to trace the European storms to Siberia, as the observations were too few for this purpose. I have tried to gain some knowledge of the subject of storms by considering the barometrical range; that is, the mean maxima and minima of each month.† I can, however, only briefly state the results: The mean barometrical minima of the winter months, reduced to sea-level, are: At Reikiavik, in Iceland, 726 millimeters, or 28.5 inches; at Hammerfest, Norway, 730 millimeters, or 28.7 inches; at St. Petersburg, 737.3 millimeters, 29.0 inches. At Barnaul, (West Siberia,) 754.7 millimeters, or 29.7 inches; at Nertschinsk, (East Siberia,) 763 millimeters, or 30.04 inches. In the last-mentioned place, the mean barometrical minima are an inch and

* In his "Storm-Atlas."

† Zeitschrift der österreichischen Gesellschaft für Meteorologie, year 1871, p. 161.

Mean monthly barometric curves.



a half higher than in Iceland. In Siberia the mean minima are also higher in January than in the other months, while generally in Europe and North America the contrary is the case, indicating a greater intensity of the storms in midwinter. In the annexed diagram the movement of the minima is graphically represented. North America and Western Europe have the same system of curves, the minima being highest in summer, lowest in winter. In Siberia and Eastern Asia the contrary is the case; this is especially marked at Pekin. The stations of Lugan, in S. Russia, and Catharinenburg, on the Ural, occupy an intermediary position, having neither the oceanic nor the true continental type. The greatest difference between the last two places being that in Lugan October has the highest minima in the year, and Catharinenburg the lowest. This is not accidental. In October the conditions of the temperature and moisture of the air on the Ural, and in Siberia, are more favorable to the propagation of storms than in winter. In the same season the Atlantic storms take a more northern course, causing a great depression of the minima on the Ural. In Southern Russia the pressure is generally high in autumn, as also the minima. October is not a stormy month there, while November and December are.

It is possible that in October Atlantic storms may reach as far as Jakutsk. The sky is generally overcast there, it is the most cloudy month of the year, and the number of west and southwest winds is great. The temperature has not yet fallen so low, even in the northern interior of Siberia, as to prevent the propagation of storms.

We shall next consider the winds, which are in so intimate a connection with the pressure of the air. I have said before that Wesselovsky had proved the existence of a belt of eastern winds during autumn and winter in Southern Russia, while at the same time the southwest winds prevail in the northern part of the country. The movements of the atmosphere are better known at the present time as far as the Jenissei, and I have been able to prove the existence of a belt of prevailing southwest winds in Northern Siberia, and of eastern winds in the south of that country and Central Asia. The division line runs about the parallel of 50° or 52° north in Siberia, and a little more south near the shores of the Black Sea.*

This is illustrated by the following table, which shows the percentage of winds in winter in Western Siberia, Central Asia, and Southeastern Russia:

South of 52°.

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Orenburg	11	17	19	8	11	17	9	7
Semipalatinsk	1	4	26	19	15	13	13	9
Raimsk, (Syo-Daria)	9	19	21	18	8	7	12	8
Astrachan	6	16	22	16	3	8	15	15

*"Tswästia" of the Russian Geographical Society, year 1871, No. 5.)

North of 52°.

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W
Eastern Ural, (three stations)	5	5	1	10	10	24	27	17
Tobolsk	4	4	7	30	21	12	9	13
Jschim	8	5	6	8	12	41	9	10
Kourgan	12	8	9	10	20	15	16	9
Omsk	4	13	6	9	10	24	16	19
Barnaul	8	13	1	5	15	44	9	5
Krasnojarsk	4	6	2	2	2	66	14	5

The prevalence of southwest winds in the northern part of the country is clearly seen in this table. Even Orenburg and Semipalatinsk, situated between 50° and 52°, have prevailing east winds, but a great number of southerly also, while Astrachan and Raimsk have much less southwest and much more northeast winds than all the other points. The differences we notice between the several points are easily accounted for, if we consider the rough mode of observing the wind-gauge and the different local circumstances having an influence on the indications of this instrument.

I have also noticed an influence of the upper river valley, the winds in the direction of this being generally more frequent. For example, at Tobolsk the Irtysch comes from the southeast, and the winds from that quarter prevail. At Jschim, Barnaul, and Krasnojarsk the rivers flow from the southwest, and so the local direction corresponds with the general one, giving an enormous prevalence to the southwest winds. At Omsk only this is not the case; the rivers flow from east and southeast, and yet the prevailing wind is southwest. This is probably due to the very level position of the surroundings of Omsk. The winds of this place can be considered as typical for Western Siberia, north of 52°, that is, a moderate prevalence of the southwest, extending also to the south and west winds. Three or four years ago nothing accurate was known as to the winds in the basin of the Yenissei. Now we know that the southwest extends as far as there, and probably even to the east of this river.

Further to the east the winds are so rare and irregular in the winter, and calms so general, that I may call this region one of prevailing calms. It embraces the basin of the Lena and the tributaries of the Northern Ocean, east and west of it, as also Transbaikalia. It is the region of the Siberian meteorological pole. The atmosphere is generally clear and calm, with cold generated on the spot by radiation, and not brought from other places by the winds. We must not imagine that this region is of equal magnitude every winter; it extends and contracts unperiodically. In very cold winters it stretches westward to the Ural, and even farther, while the warm winters of Western Siberia are those in which it shares in the atmospherical currents of Europe. To prove this I calculated the temperature of the winds at Krasnojarsk in the

winter months of 1870–'71, as given in the following table, in which N. C. indicates the number of winds observed:

Month.	N. E.		E.		S. E.		S. E.		S. W.		W.		N. W.		Calms.	
	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.
December..	0	.....	0	.....	1	−35.5	0	.....	44	0	5	−24.7	6	−4.0	37	−27.6
January ...	9	−12.3	4	−11.0	0	.....	0	.....	55	0.7	9	−6.7	0	.....	16	−13.2
February ..	5	−1.5	1	24.6	2	21.2	6	9.0	46	1.4	9	5.2	2	−19.1	13	9.5

The temperatures of the months were: in December, —12.2; January, —4.2; February, 4.0. February is much warmer than December, yet the temperature of the prevailing southwest winds is nearly the same, differing only 1.4, while the mean temperature differs by 16°.2. But we see that in December calms were much more prevalent than in February, and the temperature of the calm days very low. To show more clearly that the movement of the air in this region tends to elevate the temperature, I have calculated separately the temperature of light, moderate, and strong southwest winds.

Month.	S.W.		
	Light.	Moderate.	Strong.
December	—3.1	—2.4	9.7
January	—2.0	1.2	13.8
February	2.1	—2.4	14.4

The strong winds are by far the warmest, the difference of temperature between light and strong being 12.8 in December, 15.8 in January, and 12.3 in February. The region of calms, or of the Siberian pole, is bounded on the south and east by that of the Asiatic monsoons, or periodic winds, blowing from the land in winter and from the sea in summer. It is only within the last year that the true extent of this interesting region has become known. In the winter the interior of the continent is cooled by radiation, the atmospheric pressure rises, and the air flows out to the Indian and Pacific Oceans, where the pressure is less. In summer the continent is heated, the pressure is much lowered, and the air from the surrounding seas flows in upon Asia. Encountering high mountains on the south and east, the sea-air is forced up into a higher and colder altitude, and loses its vapor in copious rains; so the gap can never be filled, as the precipitation causes a low pressure near the mountain sides. These movements of air are especially marked in Southern and Eastern Asia, because the heated plateaus of the inte-

rior are there nearest to the ocean. Air is also drawn into Central Asia from the Arctic and Atlantic Oceans, but, having a much longer distance to travel before reaching the mountains, and being originally colder, it does not cause such a great precipitation. The in-draught from the north and west is also less regular, since the pressure over the Arctic is not high in summer, and the air of the Atlantic is also drawn toward the deserts of Africa where the pressure is low in summer.

The Asiatic monsoons were first known to the Europeans in India, and therefore we often find them called Indian monsoons. It is also supposed that they always blow from the northeast in winter, (dry monsoons,) and from the southwest in summer, (wet monsoons.) In the lately published "pilot-chart" of the British admiralty the monsoon region is represented as extending northward to Southern China only. But the winds much farther to the north have the same periodical character. Even in Northern China, Japan, Mantschuria, the Russian Amoor provinces, and on the western coast of the Sea of Ochotsk, cold, dry winds (northwest) from the interior of the continent generally prevail in winter, while in summer they are from the sea, bringing cloud and rain. There is, therefore, no reason why we should not extend the Asiatic monsoons to these countries, since their climates are of the same character as that of India, the temperature alone excepted, the winter being the clear, dry time of the year, and the summer being the rainy period. Sometimes the summer monsoon extends as far inland as Lake Baikal. In 1869 this lake, the greatest fresh-water basin of the world except Lake Superior, rose more than 10 feet above its ordinary level, causing disastrous floods in the neighborhood. Such copious and long-continued rains in summer are unknown in European Russia; the great rivers are unaccompanied with freshets in summer, especially those traversing great lakes, as the Neva.

The following table shows the periodical character of the winds in the regions of Eastern Asia:

Percentage of winds at Nicolajersk, mouth of the Amoor.

Months.	N.	NE.	E.	SE.	S.	SW.	W.	NW
January	10	2	1	0	0	4	57	26
February	10	4	3	1	0	3	42	36
March	16	11	13	4	1	3	30	23
April	6	14	31	9	1	3	23	13
May	5	14	35	14	1	1	20	9
June	3	18	42	20	1	1	8	6
July	6	9	46	14	1	1	15	9
August	6	10	36	9	1	2	13	23
September	10	13	19	9	0	2	21	36
October	9	12	12	4	1	3	31	29
November	7	5	4	3	0	3	37	40
December	10	6	4	1	1	5	50	22

The western winter monsoon is established as early as the end of September; that is, in the time of the typhoons of the Southern China seas. The navigators in the Sea of Ochotsk have long known the periodicity of the winds in this region, of which they take advantage in going in the summer from Kamtschatka to the western coast of this sea, and returning in September or October, when the western winds have fairly set in.

The extremely unpleasant cold and damp summer climate of these regions is caused by the prevailing east wind coming from the cold Sea of Ochotsk, a true polar basin transfered to a lower latitude. The yearly increase of temperature is also checked to a great degree by this influence, the warmest month being generally August, when the sea-water has acquired a higher temperature.

The summer rains are very copious, even in places inland as far as Pekin. In this place, as also at the mines of Nertschinsk, the fall of water is more than fifty times larger in July than in January. In the last place there is hardly any sledging in winter, though the temperature remains six months below the freezing-point. The countries on the Lower Amoor and Japan have more of snow and rain in autumn and winter. The east winds from the adjoining sea are seldom experienced, yet when they do occur the precipitation is copious, the difference of temperature between land and sea being very great. We find a resemblance to this in the climate of Eastern North America, where the rain-fall is more copious than in Europe; yet the sky is clearer and the number of rainy days less.

Precipitation in inches.

	Year.	Winter.	Spring.	Summer.	Autumn.	Greatest.	Least.
Pekin	24.21	0.64	2.23	17.36	4.00	8.06 July.	0.14 Jan.
Nertschinsk	15.47	0.30	1.73	10.64	2.80	3.96 Aug.	0.07 Feb.
Hakodadi, Japan	44.01	8.14	8.49	16.46	10.94	8.21 July.	1.89 Jan.

I have said before that the monsoon climate is characterized by a generally clear winter and a rather cloudy summer. The amount of cloudiness has only begun within the last few years to attract the attention of scientific men. An extensive collection of tables of this element has been commenced by Kamtz, and continued by Wild, who has published the results in the new "Repertorium für Meteorology." They embrace many places in Russia and in Siberia. I present here an extract from these tables, in which the means of several places have been combined together. The amount of cloudiness is expressed in percentage; a cloudless sky taken as zero.

	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	Year.
(1) Alaska:													
Sitka	63	65	66	61	63	66	72	75	74	71	73	68	68
(2) Eastern Asia:													
Pekin	23	25	31	39	46	49	56	63	56	46	30	32	42
Ochotsk, Ajan, Nicolajevsk	26	25	27	35	37	48	47	48	50	44	35	34	37
Mines of Nertschinsk	19	13	14	22	36	44	47	48	46	44	38	25	33
(3) Central and West Siberia:													
Jakutsk	46	46	35	26	37	49	49	47	49	55	69	48	46
Barnaul	51	41	39	35	38	37	39	38	38	55	46	54	41
Tobolsk, Tara, Tschim	54	46	43	41	42	44	45	44	47	40	58	58	48
Bogoslowsk and Berezov	42	43	40	38	43	46	44	43	46	53	52	50	45
(4) Central and Northern Russia:													
Weliki-Ustjug, Glazov, Slobodskoi	66	60	61	52	47	42	40	34	43	49	67	71	52
Ardatov, Balachua, Gorbatov, Tambov, Simbirsk, Wolsk	66	60	60	50	49	44	42	42	41	47	62	68	52
Anandus, Reval, Baltischport, Riga	59	54	52	48	44	38	37	34	35	44	56	61	47
Yozki, Kaluga	75	76	65	59	49	43	42	41	42	50	64	74	55
(5) Southern Russia:													
Kursk, Orel	70	63	58	50	47	40	38	38	37	47	55	65	51
Sudscha, Lugan, Catherinbosburg	72	63	64	57	42	33	31	31	30	38	52	68	48
Odessa, Nicolojev	73	70	63	62	52	44	40	36	32	36	49	68	52
(6) Southeastern Steppes:													
Astrachan, Ft. Alexander, Uralsk	57	57	49	43	34	28	26	24	21	24	34	39	37
Raimsk, Kasalinsk, and Fort Perovski	46	41	40	37	27	28	25	23	19	20	24	34	30
(7) Caspian:													
Baku, Lenkoran, Ashur-Ade	59	59	64	62	56	48	44	38	39	46	49	59	51

The contrasting climates are those of European Russia and Eastern Asia, the first having the greatest amount of cloud generally in December, the last in July or August. The greatest part of Siberia is a land of transition, having the least amount of cloud in March and the greatest in October or November. Barnaul has very little cloudiness from February to August, so as to form a transition between the steppes on the southwest, and the countries on the east of it. Yet it must be said that the accuracy of this table is not very great, the amount of cloudiness not being observed in former times in Russia, and only such designations as clear, cloudy, overcast, &c., being given, and sometimes also the different qualities of clouds, (*cirro cumulus*,) &c. It seems especially that the amount of cloudiness in Southern Russia is less than that shown in Wild's table, and the same probably applies to the southeast steppes. In regions where the sky is clear for some weeks together the observers will record "cloudy" if only a few clouds appear, &c. A cloudiness of from 70 to 72 at Odessa and Lugan seems to me quite impossible.

I have already spoken of the summer winds in the monsoon region. In the region of the southwest winds the change from winter to summer is far less marked, the winds being a little more from the north in sum-

mer, the prevailing direction being still west. In the steppes of Southern Russia, and far into Central Asia, the winds are also west in June and July, the prevailing direction being the opposite of that of winter. Yet this has not so great an influence on all the features of the climate as in Eastern Asia—1st, because winds from other directions are more or less common in both seasons; and 2d, because there is not the contrast existing in Eastern Asia between the winds from the continent and those from the ocean.

In Transcaucasia the winds are also generally easterly in winter and westerly in summer, as on the northern shores of the Black Sea. Yet the influence of the mountains and sea is strongly felt. On the Caspian, especially, the day and night breezes are very regular in summer. The Persian sailors know this very well, and in going from the south to Astrachan they keep along the eastern shore, where the breezes are stronger than on the western.

We possess very few observations on the quantity of falling water, and this has induced the Geographical Society to establish a more general system, especially for this element. Yet we must wait at least from ten to fifteen years before having reliable data from the new stations. Some general features can, however, be ascertained even now, with the aid of the few points of observation we possess. In a work on the rains of Russia* I have divided the country thus:

1. Region of prevailing summer rains, with a maximum in July: Including the northern part of Russia and Siberia as far as the 50° in the west, and 54° in the east.

2. Region of prevailing summer rains, with a maximum in June: Including the country south of the former, being the principal part of the steppes (prairies) of southern and eastern Russia.

The two regions differ, moreover, in this, that the second has a very marked dry time in September and October, with easterly winds, and a second maximum in November.

Possibly the difference of the time of most copious rains coincides with the physical aspect of the country, being well wooded in the north and nearly naked in the south. In the beginning of the summer the grasses and corn-fields of the steppes are green, and in this condition the evaporation is considerable, giving enough of vapor to the air, while at the same time the cold caused by evaporation is favorable to the condensation of moisture. In July the grasses are already withered, the corn ripened, and in these conditions the plants evaporate much less water, and therefore the rains are less frequent and copious.

In the wooded region of the north evaporation from the leaves of trees goes on the whole summer, the best conditions for rain being in July, the hottest month. In the United States the conditions are similar. The country east of the Rocky Mountains is also principally one of

*To be published in the "Sapiski" of the Russian Geographical Society; also, "Zeitschrift der österreichischen Gesellschaft für Meteorologie," year 1871, p. 193.

summer rains, but in the prairie States the maximum of falling water is reached earlier; so in Missouri and Kansas there is a marked maximum in June; farther to the south even in April and May, which is due to the earlier vegetation. In the wooded Atlantic sea-board, on the contrary, there is no such tendency to an early maximum, the rains being very equally distributed in the Northern States, and having a maximum in July or August in the South.

Besides the above stated difference between the north and south, there is a marked one between the east and west of Russia. Precipitation in winter is much less in the former. This is not due to the difference of the currents of the air, but to the winter cold, which is greater in the east. The warm, moist southwest winds contain little vapor in Eastern Russia, and therefore the quantity precipitated cannot be great. Yet snow falls occasionally, and in small quantities, even at Jakutsk, which has the coldest winter of which we have any knowledge. Snow-falls have been observed there at temperatures of from — 40 to — 46 Fahr. The rain-fall of summer does not diminish generally from the Baltic to the Obi in Siberia. Local circumstances seem to have a great influence on the summer rains, but their study requires many more observations. There are also two small regions with prevailing rains in autumn—one on the Baltic coast, comprising Southwest Finland and Libau; another in the southern part of the Crimea, south of the Jaila Mountains.

3. Nearly rainless region of the Caspian and Kirghez steppes. Here the amount of rain falling yearly is from 4 to 6 inches, and is very irregularly distributed. It is an arid, desolate country, in which agriculture is impossible without irrigation. The boundary of the region of summer rains No. 2 is very clearly marked on the west. It is the high, right bank of the Volga from 50° to 48° N., and a line of heights called Jergeni, forming its continuation to the south, extending to the Kuma-Manytsch depression, about 46° N. On the south of this depression the plateau of the Western Caucasus rises, and its eastern border is also the line of division between the two regions, the eastern being low, salt, and desert; the western having regular summer rains, and a luxurious natural grass vegetation. A great part of it is already under cultivation, yielding excellent corn-crops.

The mountains of Central Asia have more rains than the steppes at their foot, and the rivers descending from them are extensively used for irrigation. The inhabitants are well aware of the benefit of this system, and, though not very civilized, have excellent modes of irrigation. The whole of Central Asia, as much as we know of it, has a similar climate, the sedentary inhabitants gathering around mountain streams, and often draining them to the last drop for their fields.

4. East of this country is the monsoon region of Eastern Asia, with an enormous prevalence of summer rains. The principal features and extent of this region have been already described. These are the four principal regions from the Baltic to the Pacific. The floods of the riv-

ers furnish us also means of distinguishing the European climate from that of the Pacific slope. All great rivers of European Russia, as also the Obi and Jenissei, have one principal flood in the year, after the melting of the winter snow. The rise of water is more or less protracted, owing to the climate and extent of the basin, so that the highest stage of water is reached as late as the 15th of June by the Volga at Astrachan, owing to the late melting of the snow on the western slopes of the Ural and the enormous distance the water has to pass from thence to Astrachan.

The summer rains are not long enough continued, and too local to have great influence on the rivers.

The Angara River, tributary of the Jenissei, does not rise generally in spring, the quantity of snow falling there being too small. But sometimes the river and Lake Baikal, which it traverses, rise very high in summer. The Amoor has also no great flood, due to the melting of snow, but rises very high sometimes in summer. The disastrous flood of 1872 will long be remembered by the inhabitants of the country. The rivers of China have also floods, due to the spring and summer rains, and, like all rivers in such condition, their floods are very disastrous and irregular.

The Caucasian provinces, though of small extent, show great differences in the quantity and character of their rains. South of the principal chain we must distinguish three principal belts: (1) that of the eastern coast of the Black Sea, a country of very copious precipitation. It includes Mingrelia, Imeretia, Guria, and Abchasia, being bounded on the northeast by the principal chain of the Caucasus, and on the east by the Suram Mountains, separating Imeretia from Grusia. About 60 inches fall in the year, which is tolerably well distributed, the maxima being in June and December. A warm climate and copious rains produce a rank, luxurious vegetation, having some features of that of the tropics. Climbing plants are especially favored by the climate, and the trees of Central Europe attain immense dimensions. (2.) Grusia has a less rainy climate, the maximum falling in May. Irrigation is found much necessary in the valleys, while the mountain-sides, from 2,000 to 5,000 feet high, are clad with forests. The maximum of rain-fall in May is strongly marked, this month at Tiflis having also the greatest number of rainy days and the greatest amount of cloud. On the higher plateau of Armenia, 4,800 feet, May is also the rainiest month, as it is due north of the Caucasian chain at Alagir. (3.) The western shores of the Caspian have sub-tropical rains—that is, the greatest quantity falls in autumn and winter, while the summer is decidedly dry. The distribution is nearly the same along all this shore, while the quantity varies much; Lenkoran, for example, has more than 50 inches, while Baku has only 10. The vapor coming from the Caspian, places having mountains to the westward receive copious rains. Lenkoran has a similar position, the Talysh Mountains rising from 5,000 to 7,000 feet due west of the

town. Baku is situated in a low, arid country north of this place. The vicinity of Kuba and Derbent has much more rains, because the ramifications of the high Shah-Dagh approach the Caspian. This country has magnificent forests and very favorable conditions for agriculture.

I have already said that the opening and freezing of rivers was long ago observed in Russia. These data give us the means of ascertaining something of climates where no thermometrical observations have been made.

In the following table the rivers are arranged according to natural basins. The principal rivers are taken from their source to their mouth, and their affluents afterwards.

Number of days the rivers were frozen.

BASIN OF THE PACIFIC.

Amoor at Nicolajevsk	193
Onon near Nertchinsk	170

BASIN OF THE ARCTIC.

Yana at Ustyansk, 70° N	260
Lena at Kirensk, 57°	204
Lena at Yakoutsk, 62°	204
Yenisei at Yenisseisk, 58°	171
Angara at Irkoutsk, 52°	87
Obi at Barnaul, 53°	167
Irtish at Tobolsk, 58°	173
Tom at Tomsk, 56°	180
Tobol at Kurgan	171
Sosva at Beresov, 64°	207
Isset at Catherineburg	179
Petchora at its mouth, about	240
Dwina at Archangel, 65°	191
Suchona at Ustjug	168
Wytschegda at Jarensk	132
Wologda at Wologda, 59°	170
Onega, 64°	169
Tana at Utsjoki, 69°	197

BASIN OF THE BALTIC.

Kemi near Toneo, 66°	207
Enoutekois, 68°	228
Uleo at Uleaborg, 65°	201
Neva at St. Petersburg, 60°	147
Narova at Narva, 59°	137
Embach at Dorpat, 58°	131
Dwïna at Witebsk, 56°	134
Dwïna at Riga, 57°	126
Niemen at Kovno, 54°	90
Vistula at Warsaw, 52°	85

BASIN OF THE BLACK AND AZOV SEAS.

Danube at Galatz, 45°	48
Dneper at Kiev, 50°	97

Dneper at Catherinenslav, 48°	91
Dneper at Kherson, 46°	80
Sosch at Gomel, 52°	122
Berezina at Borissov, 54°	129
Pripet at Turov, 52°	105
Don at Ust-Medvedizo, 49°	135
Don at Aksai, 47°	107
Woroneje at Woroneje, 52°	135
Lopan at Charkov, 50°	127

BASIN OF THE CASPIAN.

Wolga at Tver, 56°	147
Wolga at Yaroslav, 58°	152
Wolga at Kostroma, 58°	161
Wolga at Kasan, 56°	153
Wolga at Samara, 53°	150
Wolga at Saratov, 51°	132
Wolga at Astrakhan, 46°	99
Oka at Orel, 53°	130
Jna at Tambov, 53°	146
Kama near Dedjuchin	180
Kama at Ussolje, 60°	176
Kama at Perm, 58°	160
Kama at Jelabuga, 56°	160
Vjätka at Vjätka, 58°	163
Bjelaja at Ufa, 55°	158
Ural at Orenburg, 51°	164

BASIN OF THE ARAL SEA.

Syr-Daria at Khodjent, 40°	0
Syr-Daria at Jt. Porovski, 45°	98
Syr-Daria at Kasalinsk, 46°	123

The time of opening and closing of rivers depends not only on the intensity and duration of frost, but also on many local conditions, as, for example, the strength of the current. On this account the Angara at Irkutsk is frozen only half the time it would be if its current were not so very strong. This river very seldom freezes near Lake Baikal, and at Irkutsk the freezing begins at the bottom. Rivers of such an exceptional character are seldom met with in Russia, as the greatest part of the country is a level plain, only slightly undulating. There seems not to be a very great difference in the time at which large and small rivers are frozen; the former freeze and open a little later. Great and deep bodies of water are not so easily cooled as small, and so great rivers freeze later. The later opening in spring has a different cause: The ice of the smaller rivers is broken by the inrush of water from melted snow. The channels of great rivers do not fill so rapidly and their ice must be more worn before it breaks. The Volga at Saratov, where it carries an enormous body of water, and the Oka at Orel, where it is a very small river, are covered with ice nearly the same number of days. But the Volga is frozen only from the 8th of December to the 19th April, while the Oka

freezes the 25th of November and opens the 4th of April. It is thus closed thirteen days earlier and opened fifteen days earlier than the Volga.

The rivers are frozen a much longer time in Eastern than in Western Russia; for example, at Orenburg the river is one hundred and sixty-four days covered with ice; at Turov, in the same latitude, the river is one hundred and seven days frozen, and at Warsaw only eighty-five days. The duration of cold weather is the principal feature of the climate to be considered. Furthermore, extremes of cold seem to have very little influence; for example, in the winter of 1870–'71, the coldest of this century, the Neva froze seven days later and opened ten days earlier than is generally the case. In this winter the cold was restricted to the months of December, January, and February, the months of November, 1870, and especially March, 1871, being comparatively warm.

An extensive collection of data relating to the freezing of rivers, lakes, and bays is in progress in Russia. It is the work of Lieutenant Rikatschef, who presented his plan to the Geographical Society in the beginning of 1870. Circulars asking for such observations were sent to every part of the empire, and it was also thought necessary to extend the work to foreign countries. I am happy to say that this plan received the hearty assistance of the late Professor Coffin, and of Professor Henry, who tried to obtain all available data from North America.

I have now briefly stated the most important facts relating to the meteorology and climatology of Russia, and will end with expressing the hope that the practical application of science to weather-forecasts may soon extend to my country, and that thus telegraphical weather-communications may encircle the globe. Everything that is useful to mankind spreads so rapidly in our day that we shall probably see at no distant date, difficult as it may seem, the system extend even to countries nearly desert, such as Eastern Siberia and Alaska. We shall then see our Baltic harbors warned of the approach of Atlantic storms many days before their occurrence, while the Russian stations on the Pacific will at the same time render a similar service to California and Oregon.

I mention here some of the principal sources of information relative to the meteorology and climatology of Russia, especially those published in German or French, which are more generally known than the Russian language.

Annuaire magnétique et météorologique, from 1837 to 1848.

Annales de l'observatoire physique central, from 1849 to 1864, containing the detailed, partly horary, magnetical and meteorological observations of the great stations.

Correspondance météorologique, from 1850 to 1864 quarterly, daily means of all stations in correspondence with the physical observatory.

Annalen des physikalischen Central-Observatoriums, (Russian and Ger-

man,) for 1865, 1866, 1867, 1868, 1870, and 1871, tri-daily means of the meteorological elements. No magnetical observations.

Repertorium für Meteorologie, edited by the geographical society, redacteur, Kamtz, 1858 to 1863; a very important source of information; valuable contributions by Kamtz and other scientific men.

Repertorium für Meteorologie, edited by the academy of sciences. redacteur, Dr. Wild, containing works on the climate of Russia by him and his assistants, appears since 1870 irregularly.

Wesselovki's "O klimate Rossie," (on the climate of Russia,) 1857. A very important source of information.

The works of the geographical society contain a great deal of information, especially some of the older volumes of the memoirs, (Sapiski,) and the year 1871 of the "Jsvastia." A new volume of the memoirs now in print is devoted entirely to meteorology. The publications of the Caucasian and Siberian branches of the society should also be mentioned. The only volume edited by the new Orenburg section, contains an important contribution by Mr. Ovodof on the winds of Orenburg.

The *Bulletin de la Société des naturalistes*, &c., of Moscow, contains meteorological observations of Moscow from 1841 to 1855, and from 1861 to 1872, as also meteorological contributions of a more general kind. *Mediko-Topograftscheski* collection, edited by the medical department of the interior, two vols., 1870 to 1872. The "*Zeitschrift der österreichischen Gesellschaft für Meteorologie*" contains many papers relating to the climate of Russia. I mention only the tables of temperature in the year 1870, Nos. 10, 14, and 15.

The Bulletin and the Memoirs of the Academy of Sciences of St. Petersburg contained much information in former times; for example, Abich's contributions on the Caucasus, in the years 1849 and 1850. Since the foundation of the "*Repertorium für Meteorologie*," in 1870, the meteorological contributions appear there.

The important works of Dove on temperature, of Buchan on mean pressure and winds, of Coffin, on the winds of the northern hemisphere, published by the Smithsonian Institution, as also Hann, "*Untersuchungen ueber die Winde der nördlichen Hemisphäre*," contain valuable information about Russia.

The publications of the universities (Utschenija Sapiski, Jsvastia, &c.) contain much information, especially in former times, when the centralization of the publications relating to meteorology was not yet begun.

Observations are also often published by newspapers, but it would be too much to mention them all here. The same may be said of some special and old works.